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VIEWS OF MEDICAL PHYSICS IN THE UNITED KINGDOM AND IRELAND, 1980

MOSES A. GREENFIELD

19 MAY 1981

UNITED STATES OF AMERICA

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This report describes activities in medical physics at some of the major hospitals in the United Kingdom and in Dublin. It includes a detailed discussion of the medical physics programs at University College Hospital, London and the University of Leeds, and briefer commentaries about other centers in the UK and three hospitals in Dublin. The report also describes the organization of medical physics in these countries and the research that is being accomplished.

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VIEWS OF MEDICAL PHYSICS IN THE UNITED KINGDOM AND IRELAND, 1980

INTRODUCTION

In the course of my tour as a liaison scientist with ONR London during 1980, I had the opportunity to observe how medical physics is organized, how it works, how it is growing, and what research work is being accomplished in a number of places in the UK and the Republic of Ireland. This report discusses some of those activities. It begins with a detailed description of medical physics in two major institutions: University College Hospital, London, and the University of Leeds. These two places exemplify the best within, and outside of, London. Following that, briefer commentaries are provided for other centers in the UK and for three hospitals in Dublin. I have also included an appendix describing the Hospital Physicists' Association in the UK, and the Hospital Physicists' Conference held at the University of Leeds in September 1980.

MEDICAL PHYSICS AT UNIVERSITY COLLEGE HOSPITAL, LONDON

The Department of Medical Physics and Bioengineering at the University College Hospital (UCH) and Medical School in London is one of the largest and quite possibly the best organized of the medical physics groups in the UK. The word "Bioengineering" in the department's title is highly significant and indicates the breadth of the department's responsibilities. The director is Mr. John S. Clifton, a very senior and highly respected scientist in the medical physics community. He is also the honorary editor of *Physics in Medicine and Biology*, the world's leading journal in the field. He serves on a number of prestigious committees including the Scientist Advisory Committee for the Department of Health and Social Security. The department includes approximately 60 persons. This makes the department significantly larger than comparable medical physics divisions or departments in the United States. The reason for the difference is the relatively greater scope of service responsibility that is involved for Clifton's department. A listing of the various components of the department gives some idea of the different areas included: the Instrumentation Group, the Transducers Group, the Computer Science Group, the Radionuclide Group, the Radiation Dosimetry Group, and the Dental Science Group. Additionally, there are the following support units: the Electromedical Unit, the Electronics Unit, and the Instrument Making Unit. The point is that not only are the activities wide ranging, but the services are supplied to virtually all the clinical departments in the medical school and hospital complex. By contrast, the typical medical physics division in the United States is located in a single department, usually that of radiological sciences, and physics support services ordinarily are offered to components of that department (Nuclear Medicine, Radiation Therapy, Diagnostic Radiology). In recent years there has been a movement in the US to set up radiation therapy divisions as independent departments of radiation oncology. (This took place a few years ago at UCLA, my home institution). When this occurs, the usual practice is to split the medical physics group into separate components, one for each department, new and old. Other medical school departments in the US often have their own instrument makers and repairmen, biomedical engineering units, and electronics specialists. These groups or units ordinarily have no liaison or contacts with each other. The UK system is superior for at least two reasons. The first is the efficiency of having a single organization with no duplication of services. The second and more important advantage is derived from the fact that the director and group supervisors are highly trained scientists who can bring the best available science and technology to bear upon the problems to be solved.

The organization of these UK medical physics departments appears to be a generation ahead of that of their counterparts in the US. To some extent this reflects the fact that medical physics in the UK goes back to the years immediately after WWI, whereas in the US there were virtually no medical physics groups in existence until after WWII. (There are two splendid exceptions: The Mayo Clinic at Rochester, Minn., and Columbia University in New York City. The names of Dr. Marvin Williams at Mayo and Drs. G. Failla and Edith Quimby at Columbia come to mind as the great leaders in the United States in those earliest times.)

In addition to the service work at UCH, the Medical Physics Department has teaching responsibilities at University College. The department offers a course in medical scientific computing for students enrolling in the MSc in Computer Science. It also gives an undergraduate course in computing techniques designed especially for medical students, and a course in ultrasound. The latter is given three times each year, and even at that frequency it is oversubscribed.

The workload related to safety and maintenance services (both radiological and electromedical) continues to grow each year. It has reached tne point at which no additional workload can be absorbed without adding more staff. This seems unlikely at the present time because of the freezing of revenue support levels. The support funds come mainly from the National Health Service (NHS), and retrenchment of funding support is the order of the day. Salary scales for the technical staff have fallen behind what is offered in the private sector.

The Instrumentation Group has been developing equipment to be used in real-time ultrasound investigations. One tecnnique uses a real-time linear-array scanner for the diagnosis of intraventricular hemorrhage in neonates. This is at the point of becoming a usable clinical tool. In a rather different direction, this group has helped to install, service, and maintain a 10-watt Argon/Ion laser for coagulation of gastrointestinal bleeding. Another important function of this group is the use of ultrasound for research work on tissue characterization. Some initial studies have been made on skeletal muscle in normal subjects.

The Transducers Group has been working on the development of oxygen and carbon dioxide monitoring equipment. A combined O_2/CO_2 transcutaneous electrode is being evaluated clinically together with a transcutaneous mass spectrometer probe.

The Computer Science Group offers support for routine clinical work in a number of areas including nuclear medicine, radiotherapy, ultrasound and neonatal monitoring. It has provided terminals and software for computer use as a teaching aid in the intensive care unit. Other research applications involving computer assistance include assessment of the calcium content of bones (*in vivo*), and analyses of tomographic scans produced by the CT unit (computerized tomography).

The Radionuclide Group has a heavy load in terms of service, and also a major role in cooperative research with other clinical departments. In a typical 12 month period, about 3,000 patients receive a total of 10,000 radioisotope scans. Research efforts include labeling bronchodilator drugs with techniques for quantifying pulmonary function, quantifying sacroiliac scanning with ^{99}mTc, quantitative scanning of bone marrow (^{52}Fe) in Hodgkins disease, and studies in marrow recovery time after radiation chemotherapy. Other research studies include determination of cerebral blood flow in elderly patients receiving drug therapy for anti-hypertension. These patients also have renal function tests with the use of ^{51}Cr. This group also has instrumentation interests which include setting up a pure germanium probe for X-ray fluorescence studies and a whole body counter for radiation protection screening of staff persons working with ^{125}I, ^{131}I and ^{99}mTc.

The Radiation Dosimetry Group carries a heavy service load because of its involvement with improved methods for radiotherapy treatments, especially for Hodgkins disease, irradiation of the central nervous system (CNS), and total body irradiation for lymphosarcomas. One of the research areas is the development of the use of computerized tomography (CT) as an aid for treatment planning in radiotherapy. This group has responsibility for radiation protection and has developed a microprocessor-based automated densitometry read-out system. Teaching duties include courses of lectures both for radiographers (technologists) and for medical staff (physicians) preparing for diploma in medical radiology (DMR) examinations.

The Dental Science Group has research interests in the biomechanics of the support of natural teeth, and in the physical characteristics of dental filling materials.

The Electromedical Support Unit undertakes the servicing and disinfection of all types of equipment (incubators, ventilators, and electromedical equipment generally) and calibration of audiometers. The Electronics Unit supports physiological measurements. An important teaching function is the training of nursing and clinical staff on the correct use of electromedical equipment.

One index to research activity is the number and quality of papers accepted for publication in refereed journals. The Medical Physics and Bioengineering Department had a respectable output of 23 papers in a recent 12-month interval.

The senior persons in the department and their areas of responsibility are:

John S. Clifton	Director
D. Parker	Transducers
P.J. Mulvey	Radiation Protection
M.D. Short	Radionuclides
R.J. Blackwell	Ultrasound
G. Cusick	Medical Electronics
D.T. Delpy	Electrophysiology

DEPARTMENT OF MEDICAL PHYSICS AT THE UNIVERSITY OF LEEDS

My visit to the Medical Physics Department at Leeds was on the occasion of the Annual Conference of the Hospital Physicists' Association (HPA) which took place at Leeds on September 24-27, 1980. I had the pleasure of meeting with Professor Roy E. Ellis, head of the department who was also the outgoing president of the HPA. He had held that office for the preceeding two years, and had been vice-president for the two years before that, making a total of four years of arduous service to the organization. As it turned out, all that time was required to achieve one of Ellis' major objectives: setting up standards for an educational curriculum for an MSc in Medical Physics. The need for training standards had been evident to all in the HPA for about the last 10 years. However, it took the efforts of Ellis and Mr. John Clifton, director of Medical Physics at UCH, to bring the matter finally to fruition, with HPA approval, by the end of 1980.

At the time of the HPA meeting I also met with one of the senior lecturers on Ellis' staff, Dr. Clement Oxby. I had especially wished to meet him to discuss his research interest in measuring bone calcium by *in vivo* methods, which is also one of my own areas of research work. Oxby has developed a neutron activation technique which leads to measurements not only of total body calcium but also of Na, Cl and P. This work by Oxby and his colleagues is being done in cooperation with Prof. Nordin (Dept. of Medicine) who heads the Medical Research Council (MRC) Mineral Metabolism Unit. I also met (through Oxby), Dr. D.A. Marshall, a physicist, who is a member of Nordin's unit and who is also doing neutron activation work on patients to determine quantities of essential body tissue elements.

Like many of the older centers of medical physics, Leeds goes back to the 1930s. The first director and professor was Dr. F.W. Spiers whose responsibilities included the safety aspects of radium, then newly acquired for use in radiation therapeutic applications. (Spiers was the person who had joined with a number of like-minded physicists in similar positions to form the HPA in 1943.) By the late 1940s Spiers had a small staff which included three additional physicists working on medical electronics and the use of radiopharmaceuticals in what was to become known as nuclear medicine. Spiers' initial appointment at Leeds University (in 1935) had been as demonstrator in physics. By 1950, Spiers was professor and head of the Medical Physics Department. He held this post until his retirement in 1972, at which time Ellis was appointed.

Medical physics at Leeds has grown in response to the growth of clinical needs not only in Leeds, but also in the greater medical area of which Leeds is the hub. In Leeds itself, three major hospitals are served by the Medical Physics Department: Cookridge Hospital, which contains the Leeds Center of Radiotherapy (established in 1956); the General Infirmary, Wellcome Wing, (established in 1960) which now houses the Department of Medical Physics; and St. James' Hospital, designated as another University Teaching Hospital in 1973. By that time the Medical Physics Department had grown considerably and had responsibilities in ultrasound, nuclear medicine and medical electronics.

One of the elements in the growth pattern for medical physics at Leeds was the establishment, by the Medical Research Council, of an Environmental Radiation Research Unit in 1959. This unit was then under the direction of Spiers, who saw to the establishment of a whole-body monitoring facility for the measurement of low-level radioactivity, particularly the estimation of whole-body potassium. This initial research was expanded in time to include the field of neutron activation analysis of tissue elements, referred to above.

A traditional responsibility of medical physicists has been to teach radiologists and radiographers (technologists) the basic radiation physics required in their crafts. This teaching responsibility broadened over the years to include the teaching and training of new medical physicists at both the MSc and PhD levels. By the end of 1980 the Department had 11 registered PhD students. The MSc degree requires 2 years of work, including didactic lectures and practical work in the hospital. Some 39 physicists have successfully completed the MSc course.

Ellis' Department includes 31 scientists and approximately 70 technologists, who carry on the extensive program of service and research. These personnel are distributed as follows: At the General Infirmary, there are 17 physicists employed by the university, the NHS or the MRC, and 24 technologists; at St. James' Hospital there are 4 physicists and 23 technologists; and at Cookridge there are 10 physicists and 22 technologists. The yearly budget for the department is about £750,000 ($1.8 million). Of the 31 scientists, only 9 have what we in the US would call tenured posts, with 50% support from the University and 50% from the NHS.

In addition to the physicists on the staff, there are 13 research persons, either postdoctoral fellows or graduate students. All but 5 (mostly foreign) have financial support. The moneys come from a variety of sources (University, MRC, NHS, research grants, SRC [Science Research Council]).

At St. James' Hospital, the Medical Physics Unit is responsible for the proper operation and use of imaging equipment (CT scanners, gamma cameras, ultrasound scanners). The unit works with and carries out some research efforts with the Departments of Surgery, Medicine, Forensic Medicine, Pathology, and Obstetrics and Gynecology. Since St. James' is a Regional Center for renal diaylsis and kidney transplantation, the medical-physics responsibilities include maintenance of these units and also of some 50 home dialysis units in the Yorkshire region.

At Cookridge Hospital, the principal activity is in radiotherapy. Major facilities include an electron source unit, two cobalt units, intracavitary and interstitial therapy capabilities.

An electronics unit assists in interfacing computers with a number of applications, especially in cardiology. There is also a regional ultrasound support service which provides consultation and maintenance help. Full maintenance is also provided for all radiotherapy machines.

Cookridge also has a radioisotope department (nuclear medicine). About half of the department's clinical work is bone scanning, one-third is liver scanning and the balance mostly brain scanning. Renal function studies are made using ^{123}I-hippuran (see *ESN* 34-10:477 [1980]) in patients with cancer of the cervix.

At the General Infirmary, duties of the Medical Physics department include both teaching and research. Being a part of the hospital, the department also has an obligation to provide support for the clinical services. As is often the case, involvement with clinical support frequently leads to research programs. An example of this is provided by the work of the Image Group of the Medical Physics Department in their work with mechanisms of visual preception. This work has led to the development of test objects for image quality control in X-ray television and fluorography. The Leeds "test object" set is well known in the medical physics world and is in considerable demand. Ellis informed me that the instrument makers can hardly keep up with the requests that come in.

The Spectroscopy Group of the department has developed methods for measuring the absorbance spectra of the skin as a means of characterization. Other studies include determination of electron dosimetry in bone tissue, radiological survey of the population dose in Yorkshire, and the use of Monte Carlo computer programs to calculate organ and tissue dose from any external radiation field.

The radiation protection service at the infirmary has used ionizing radiation calorimetric techniques for the measurement of ultrasound energy absorption. This has made it possible to measure the true absorption characteristics of tissues, thereby providing much-needed information. (See *ESN* 34-10:478 [1980]).

The Medical Electronics Group has been concerned with the development of microcomputer systems for a number of clinical applications. There is a special program to monitor the performance of pacemakers, particularly when they are exposed to transient magnetic fields, in order to assess the risk from this cause.

The Computing Group has put much of its effort into work on microprocessors, and into assisting and advising other hospital departments in their use.

OTHER RESEARCH PROGRAMS

In cooperation with the Science Research Council's Rutherford Laboratory, a study is being made of the use of π^- mesons for radiotherapy. There will be a π^- meson beam as part of the new spallation neutron source at the Rutherford Laboratory. The Leeds group is responsible for investigating the radiation distribution of medical x-ray treatments to estimate the risk of induced cancer per unit dose.

There has been an observation in radiotherapy that nervous tissue is more radiosensitive to neutron irradiation than to irradiation by X-rays. For this reason a study is being made of the damage to the myelin sheath of nerves caused by X-rays and by neutrons.

The properties of two-dimensional images are being studied with application to diagnostic x-ray imaging systems. These studies include the psycho-physiological mechanisms by which such images are perceived.

There is an *in vivo* neutron activation analysis program utilizing a whole-body counter. The latter has eight sodium iodide detectors in a low-background room and a 14 MeV neutron generator with an output of 3×10^{10} n/s. Studies are made of the changes in body composition in health and disease. This arrangement makes it possible to measure N, Na, Cl, P and Ca; techniques are being developed to measure H, O and C. Some applications are: (1) study of loss of protein caused by surgery; (2) Changes in skeletal calcium in rheumatoid patients undergoing drug therapy; (3) changes in body composition of the slimming obese patient.

In addition studies are being made of the lean-body mass in patients and in athletes by measuring total body potassium on the basis of measurements of naturally present radioactive ^{40}K (half life is over 10^9 years).

Bone tissue composition is measured on the basis of a gamma-ray absorptiometry technique (widely used around the world and developed by John Cameron, Univ. of Wisc.). The studies are made for longitudinal studies of the development of boys between the ages of 10 and 15 years, and of patients with renal disease. One of the senior staff members on this project is Dr. Clement Oxby. He and a postdoctoral fellow, Dr. Derek Pearson, met with me in Manchester to discuss the possibility of a cooperative research effort with me and my colleagues at UCLA to utilize our ultrasound approach in the studies of cortical bone properties. Initially they will attempt to duplicate our equipment at UCLA in order to be able to measure the speed of ultrasound. They already have the capability to measure bone dimensions, and need only to build the ultrasound component and associated electronics to be able to make time-of-flight measurements of reflected ultrasound beams.

The physicists on Ellis' staff carry on the teaching, research and service programs. In addition to Ellis, who heads the department, they are:

<u>Radiobiology and Dosimetry</u>
- Prof. P.R.J. Burch
- Dr. A.J. Walker

<u>Medical Electronics and Computing</u>
- Dr. F. Hepburn
- Mr. R. Price
- Dr. M.J. Sorel
- Mr. G.E. Tomlinson

<u>Whole Body Monitoring and Neutron Activation</u>
- Dr. L. Burkinshaw
- Dr. C.B. Oxby
- Dr. D. Pearson

<u>Imaging</u>
- Mr. G.A. Hay
- Dr. M.S. Chesters
- Mr. A. Cowen

<u>Spectroscopy</u>
- Dr. J.B. Dawson

<u>Nuclear Medicine</u>
- Dr. A.H. Smith (Honorary Lecturer)
- Dr. M.C.J. Barker
- Mr. J. Mounsey

<u>Radiation Protection</u>
- Mr. M.L. Ramsdale

On the occasion of a visit by Ellis to ONR on December 9, 1980, I learned a bit more about even greater responsibilities that fall on his (and his group's) shoulders. In fact, the Leeds Medical Physics Department has supervised radiation safety practices in the hospitals of the greater Yorkshire region, with a population of 3 1/2 million persons, since 1972. This area has a total of 80 hospitals in Bradford, York, Harrowgate, Wakefield, Grimsby, Harrow and Hull. Ellis spends 1/2 to 1 day per week visiting these outlying hospitals on a rotating basis.

An interesting request for forensic research came to Ellis from the Home Office. The question posed was whether it was possible to develop an accurate method to determine how many hours had elapsed after a person was killed by gunshot. Evidently the application was to combat terrorism and assassinations, and the time factor would provide an important clue. Ellis reported that one hopeful approach would be to study the heart pulse rate, which appears to continue, albeit at a slowing pace, for some hours after the gunshot wound has been inflicted. Records taken have already shown the following: if the time scale of several hours (say 1C or so) is reduced on recorder paper to occupy only 6 to 8 inches, one can observe a reasonably regular pattern with slowly increasing time intervals between pulses as time proceeds. This project is in progress at the present time.

Ellis is a highly respected research scientist and is frequently called in as a consultant in radiation protection studies. He was a major advisor in the recently completed study of the gonadal significant dose delivered to the population of the UK in 1977. This study was performed by personnel at Harwell. (See *ESN* 35-1:23 [1981]).

He is presently working with a colleague at Dublin on an epidemiological study of 10,000 patients treated 20 years ago for acne who received a radiation dose to their thyroid glands during the treatment. Many of these patients would have developed thyroid nodules and in some instances thyroid cancer. There are a number of similar studies now being carried on in the United States. This study is funded by the EEC of which Ireland is a member.

RADIATION PHYSICS SERVICES IN THE BIRMINGHAM AREA

Regional Radiation Physics and Protection Services (RRPPS) for the West Midlands are organized by a regional health authority with personnel centered at the Queen Elizabeth Medical Center. This arrangement, whereby the presence of a strong medical physics group at a university-centered teaching hospital is exploited to provide regional services, follows similar patterns for University College London and the University of Leeds in Yorkshire. The senior persons at Queen Elizabeth Center are Mr. R.F. Farr, chief physicist, and Dr. B.L. Reece, principal physicist.

The number of persons designated as radiation workers in the West Midlands, and thus requiring personal film dosimetry, is a staggering 6,600. This is more than all the radiation workers in Israel, (some 6,000 [See *ESN* 34-6:288 (1980)]). For Queen Elizabeth and the Yorkshire area, this number represents a substantial increase (15%) over the figures for the previous year. Another increase of 15% is expected in 1981 because of the general increases in the use of both X-rays and radiopharmaceuticals in nuclear medicine. The standards for radiation protection for workers are high, and they are adhered to rather well. During a 1-year period, no person received more than the maximum permissible whole-body dose, and only four received more than 3/10 of this value. For special purposes (e.g. checking doses received by radiation workers in their extremities) use is made of thermoluminescent dosimeters (TLD). However, these are a bit more expensive than film, and film does provide a convenient permanent record.

The responsibility of the RRPPS includes the monitoring of 200 major X-ray departments and nuclear medical services. Each is visited on a rotating basis an average of once in 15 months. In addition, the RRPPS is responsible for the radiation safety of more than 100 dental clinics in the region. The group is also responsible for ensuring that departments using radionuclides for imaging, diagnosis or therapy (some 50% of them) are in compliance with a number of statutes (Medicines Act, Ionizing Radiations Regulations). By contrast, there is a federal Bureau of Radiological Health (BRH) in the US which sets out standards by publication in the Federal Register in accordance with the applicable laws. However, enforcement ultimately lies with individual states which vary considerably in the types of legislation and enforcement they invoke. The BRH does a splendid job of coordinating with states, offering advice and help, and also offering educational programs for training persons at the state level. I believe the British system is better, and probably less costly.

Another important service offered by the RRPPS is response to requests for advice from radiologists who may have concerns about radiation doses to some patients. The services also advise hospital authorities, architects, and engineers in the proper design and use of hospital buildings from the point of view of radiation safety, and the proper methods of disposal of radioactive waste (from nuclear medicine procedures). Of course, such materials are quite short lived and disposing of them does not present as difficult a problem as coping with long-lived radioactive wastes from the operation of nuclear power plants.

When a new X-ray installation is "born", an intensive check is made on the performance of the X-ray tubes. However, there aren't enough personnel to carry out an annual follow-up quality-assurance program. The RRPPS estimate that about 230 X-ray units in the region require this kind of follow-up service over a period of 1 to 2 years. It would take one more physicist and two technicians to do this. Requests for these additions have been made, but general tightness of NHS budgets makes increases of personnel difficult.

In addition to X-ray protective services the group also monitors safety aspects of ultraviolet, microwave and laser radiation. The group has an educational training program for radiological safety officers and usually the courses are oversubscribed. These are short courses lasting just 2 1/2 days. The RRPPS cooperate with the Medical Physics and Biomedical Engineering Department at the Queen Elizabeth Medical Center in teaching and in supervising MSc and PhD research projects.

MEDICAL PHYSICS ORGANIZATION IN DUBLIN

Mater Hospital, the first hospital I visited in Dublin, has a workload of approximately 100,000 patients per year as a general hospital. The Nuclear Medcine Department is headed by Joseph T. Ennis, M.D. Others on the staff are Noirin Shehan, a medical physicist who specializes in studies of lung function, and Sean Darby, M.D., a nuclear cardologist. About 50 percent of the patient studies in the department are of the circulation (cardiac, venous and arterial systems, and lymph systems), 40 percent are studies of bones, brains, kidneys, and thyroid glands, and 10 percent are studies of other parts of the body. They also do some studies of "cold" iodine pool (^{127}I), and use fluorescent techniques for this (a number of institutions in the US are also doing such studies). The department has 3 gamma cameras for imaging, (a PHO Gamma 4, LFOV [large field of view] and LEM [low energy mobile]) plus three dedicated computers to handle the data output of the cameras.

The second hospital whose nuclear medicine department I visited was St. James, affiliated with Trinity College, Dublin. The medical physicist is Dr. Michael S. O'Connor, and the consulting radiologist is Patrick J. Freyne, M.D. O'Connor recently earned his PhD degree with thesis work on the radiobiology of the thyroid. More specifically, he studied the response of sheep thyroid cells *in vitro* to single doses of X-rays. He demonstrated that in the absence of cellular proliferation the cells tend to be radioresistant, at least for doses up to 9 krad, showing little sign of interphase death. He has published this work in the *British Journal of Radiology*, 53, 126-141,1980.

At the third hospital, St. Vincents, the chief of the Nuclear Medicine Department is George Duffy, M.D. (he trained in nuclear medicine with Prof. Dr. Nardo at the University of California, San Francisco, and also at Stanford University). About 30 patients are seen by Duffy's department each week, one-third of them for studies of brain and bones, one-third for renal studies and the remaining one-third for thyroid studies. The medical physicists working with Duffy are Michael Casey, PhD, and Miss Fionala Barker. Casey served for a while as the secretary of the Irish Health Physicists' Association (IHPA). The current secretary is Dr. David Dowsett of Mater Hospital. The IHPA is a relatively new organization, founded in 1975. Actually, the history of medical physics and radiation protection in Ireland goes back virtually to the time of Marie and Pierre Curie's isolation of radium from pitchblende in 1898. Shortly thereafter Prof. John Joly of Trinity College, Dublin acquired a small quantity of radium for research purposes. An early attempt was made in 1910 in cooperation with Dr. Walter Stevenson to treat a rodent ulcer. The two men worked together to produce a radium needle, a way of encapsulating the material for therapy applications, which was inserted into the center of a tumor for greater effectiveness. They learned how to withdraw the radon gas emanation from radium, fitting the gas into fine glass tubes which were then placed into steel needles. This technique became known as the "Dublin Method." The modern development of medical physics followed that of other countries (UK, US) and today includes nuclear medicine, radiotherapy, radiodiagnostics, ultrasound, computers and bioengineering. There is now a countrywide National Radiation Monitoring Service which provides a film badge personal dosimeter service. It also administers surveys of genetically significant doses (See *ESN* 35-1: 23 [1981]) delivered by diagnostic radiology. The service also has an educational function, giving courses on radiation safety and protection.

The IHPA is affiliated with the International Organization of Medical

Physics (IOMP) which meets every 3 years. The last meeting, in 1979, was held in Jerusalem, and the next, in 1982, will be in Hamburg, West Germany. The IHPA has recently organized a 3-year part-time training course for basic grade (beginning) medical physicists, which includes studies in applied radiation science, bioengineering and electronics.

One of Dowsett's areas of study is the assessment of lung function. A technique employed by many investigators of lung function is to use radioactive Kr-81m for ventilation imaging. The Kr-81m has a very short half-life of 13 sec., and has the good feature of providing immediate dynamic ventilation images, using a gamma camera. In a recent paper, Dowsett and some colleagues from Univ. College Hospital, London (*J. Nuc Med* 20, 3, 194-200, 1979) made a comparison between the information obtained from using Kr-81m (See *ESN* 33-4:159 [1979]) and monodisperse Tc-99m-labeled aerosol particles, in lung-function studies. The particles were 5-micron Tc-99m-labeled polystyrene. This material was used in volunteer health subjects as a control group and in patients with chronic obstructive airway disease (COAD). The idea was to measure the proportion of aerosol which reached the peripheral region of the lung compared with that deposited in the larger central airways. This ratio is defined by the authors as an aerosol penetration index, which they regard as a measure of airway potency. The healthy subjects included 5 non-smokers and 3 smokers; there were 5 patients with COAD. The tests were conducted with carefully controlled breathing patterns, and the gamma ray camera was used to measure the time history of radioactive counts in both lungs, each subdivided into 3 regions. Despite the small numbers of volunteers and patients a significant difference ($p < 0.01$) existed between the patients and normals in all cases. The authors conclude that the aerosal technique, if properly controlled, can be a more sensitive test for early lung abnormality than Kr-81m ventilation imaging.

CONCLUSION

In compiling this report, I have made a careful effort to include all the developments that appeared most significant to me in the various medical physics departments I visited. I would be remiss, however, if I were to bring my remarks to a close without commending the dedication of the staff I met in those departments and the high quality of the work they are doing. In my opinion, the UK is outstanding in Europe for the quality and scope of its research efforts. At the same time, when one considers the relatively small size of the Republic of Ireland and the more limited financial resources available there, it can be said with accuracy that the medical physicists of that country are doing very creditable work indeed.

APPENDIX

THE HOSPITAL PHYSICISTS' ASSOCIATION AND THE ANNUAL CONFERENCE, AT THE UNIVERSITY OF LEEDS (September 24-27, 1980)

The Hospital Physicists' Association (HPA), which was formed is the scientific-professional society for medical physicists in the UK. There are some similarities and a number of differences between the HPA and its American counterpart, the American Association of Physicists in Medicine (AAPM) organized in 1956. Both organizations have similar aims as scientific organizations: to advance knowledge and to help disseminate it by publishing in the open literature, and through the work of specialized scientific committees. The HPA has undoubtedly managed to represent the interests of its members in a professional sense to a much greater degree than the AAPM. This is partly because many of the HPA members are employed by hospitals through the National Health Service (NHS), and the HPA is accepted as the official representative in matters concerning working conditions, salaries, etc. While not relating directly to the HPA, the medical physicists at university teaching hospitals are usually organized into an independent department, with an independent budget, offering services to all the other departments. By contrast, a more usual arrangement in the US is to have medical physicists located in a division of a radiology or radiation oncology department. If scientific services are offered outside the home department, it is due to the energy, talents, and perceptiveness of the medical physicists at the institution. Considering the sizes and populations of their respective countries, the HPA, with 1,300 members, and the AAPM, with 1,800 members are remarkably close in numbers. Of course, the HPA has a substantial number of foreign members (this writer is one). Furthermore, "ordinary membership", (i.e. full membership) in the HPA requires only that one have a university degree in physical science, and be working in physical science applied to medical or related biological sciences. The AAPM requires 2 years of such work in addition to a university degree as prerequisite for full membership. The HPA also encompasses what may be called bioengineering activities (medical electronics, computer science, physiological measurements) to a degree not always present in a typical US medical physics group. In the sense that these more numerous activities are essential in a modern hospital and are more efficiently accomplished by an integrated organization, the UK mode is probably superior to the practice in the US.

The journal published by the HPA for refereed papers is found in libraries worldwide and is highly respected for the excellent quality of its papers. Until 6 or 7 years ago this journal, *Physics in Medicine and Biology* (*PMB*), also served as a major journal for members of AAPM who wanted to publish articles. In 1974-5, however, AAPM launched its own journal, *Medical Physics*. Unfortunately, this writer could not find copies of the AAPM journal in some European countries (including Eastern Europe), and even had some difficulty in locating *Medical Physics* in London.

Now, some observations about the annual meeting. The first morning was devoted to a "Professional Group Meeting of the Association" open to

HPA members only. The serious matter of salary negotiations was discussed after a report made by Dr. Penelope Roberts (from the Medical Physics Dept. at the Univ. of Birmingham). Roberts represents the HPA in matters of salary negotiation as the HPA representative on the Whitley Council. This council, with several dozen members, represents the health professionals (but not physicians or nurses who have other arrangements) in negotiations about salaries and working conditions with management, in this instance the NHS. The most recent salary rise (at the time of this writing) that Dr. Roberts and her confreres had negotiated was approximately 14% for the year. This was not as glorious as it might have appeared when one considered that the inflation rate had been 20-21% per annum, and was only recently being reduced to perhaps 19% or so. (Roberts informed me that she spends an average of one day per week in London attending Whitley Council meetings.) NHS recognizes four grades of scientists: basic, senior, principal, and top grade. The salary ranges offered by NHS as of April, 1980 for these four grades were respectively: £4839-7110; 7674-9922; 9720-13635; and 13705-16280. There were also some special extras for lecture fees and what are called "plussages". For comparison, the basic grade salary range translates into approximately $12,000 to $17,500. Even in absolute terms this does not compare well with typical salaries in the US. It is even worse if one notes that prices in the UK are very high. Very often £1 ($2.40) purchases goods and services in the UK which could be obtained in the US for $1. Similar comments could be made for the remainder of the salary scales.

The afternoon of the first day, of the HPA Annual Conference featured a single speaker, Mr. C. Gregory, the chief scientific officer of the DHSS, (Department of Health and Social Security) an arm of the NHS. Gregory is a former member of the HPA and is a supporter of the organization. He spoke about the scientific services supported by NHS, especially the radiation-protection work performed by HPA members in all the UK hospitals. He made the point that the DHSS depended on HPA and its scientific committees for the expertise and consultation required by his department. It was evident that a good rapport existed between the HPA and the DHSS. There is simply no corresponding relationship in the US between the AAPM, and, say, some arm of HEW.

The scientific sessions were held on the second and third days of the meeting, Thursday and Friday. In addition to orally presented papers there were informal poster sessions on-going in the hallways. The Thursday morning session was on diagnostic radiology. Several papers were presented on the description and use of the "Leeds Test Objects" in hospitals. These are logically designed devices which are used in quality control and performance measurement in intensifier fluoroscopy.

There were several papers on the use of computerized tomography (CT) scanners as aids in planning radiotherapy treatment of patients. Prior to the era of CT one major problem in radiotherapy treatment planning was the uncertainty about whether or not the planned radiation fields covered the complete tumor volume. The availability of CT, and its use for this purpose, is a major step forward in treatment planning.

In the Thursday afternoon session, J. Mason (Pinderfields Hospital, Wakefield) described a microprocessor-based data-input terminal for use in a neurosurgical intensive-care ward. The terminal is available at bed-side and can accept more than 60 items of data (physiological and nursing observations) related to severe head injuries. It relieves the nurses of much of their chore of chart recording. Additionally a data base is being constructed.

Another paper discussed the use of a microcomputer to analyze flow-volume data on-line which is obtained in ventilatory function tests. Results of calculations are displayed on a storage oscilloscope along with the original flow-volume curve. The system was described as being a "cheap add-on facility" to a ventilatory function testing system.

Derek Pearson, a postdoctoral fellow at Leeds, described a microprocessor for analyzing data from a bone scanner. The basic bone data is derived from absorptiometry measurements using a gamma ray beam, 60 keV photons from a 241 Americium source which scans the femur. The microprocessor is a Motorola M5800 with 512 bytes static RAM, 16K bytes RAM, 4 input/output ports, a scaler/timer board and resident programs in EPROM. The scanner is used to study female post-menopausal rheumatoid arthritics.

One of the more interesting posters described the recently completed study of "The Current Contribution of Diagnostic Radiology to the Population Dose in Great Britain" by a group from Harwell (B.F. Wall, S. Rae, G.M. Kendall, S.C. Darby, P.C. Shrimpton, E.S. Fisher, S.V. Harries. (See *ESN* 35-1:23 [1981]). The last such survey had been carried out 20 years previously. This new look at the risks from medical exposures in UK hospitals was especially important because it came at a time when 50% more radiographs were being taken per unit population currently than had been done previously. The results showed that despite the increases in numbers of radiographs, the genetically significant dose (GSD) to the population of Great Britain from diagnostic radiology had not increased. This favorable result was due both to the use of better techniques and to superior imaging materials that had become available.

Two posters had interesting implications for improved studies with babies and neonates. The so-called "cot deaths" have led a team from the University of Sheffield (A.J. Wilson and C.I. Franks) to develop a breathing and heartbeat analysis system for babies. They use portable tape recorders to measure the ECG and the respiration of premature babies. Computer techniques are used to analyze recorded 24-hour data tapes. The computer analyzes respiratory and heart rates and also so-called respiratory pauses. This approach may identify those babies having cardiac abnormalities.

In a development at Nottingham City Hospital (H.R. Stockdale, R.E. Richardson, P. Davies) a real time ultrasound probe is being used to examine neonatal heads with a linear array. The ultrasound is used to examine the neonate's cerebral anatomy, particularly the continuity of the ventricular system. The technique can only be used with neonates from 30 weeks to term because of the excessive sound absorption of the increased skull thickness of normal-term neonates.

The Friday morning session was on the subject of rehabilitation aids for the handicapped. One paper from The General Infirmary at Leeds (M.I. Ellis; B.B. Seedhom, V. Wright) presented a study of the forces in the knee joint while rising from normal and motorized chairs. For rising from a normal chair, the knee joint forces were found to be up to seven times body weight at the time when the body left contact with the chair. Using a specially designed motorized chair, the knee-joint forces were reduced to less than body weight until normal standing was achieved.

The final scientific session on Friday afternoon was on the value of determination of body composition. The first paper reviewed the work of the Leeds group on measuring masses of protein, fat, minerals, and water, and estimating the energy expenditure of human subjects. Neutron activation analysis was used to measure body element composition. Based on more than 1,000 measurements it has been determined that:

(1) Patients not fed intravenously (IV) after surgery lose about 10% of their protein.

(2) Patients who gain weight with IV feeding do so because of water gain.

(3) Protein is conserved if lipids rather than glucose are used as an energy source.

(4) An elemental diet can be used as an alternative to IV feeding to maintain body protein.

A new method for measuring body fat by photon absorptiometry, using a fluorescent X-ray source, was presented by E.G.A. Aird, CE Davison, and M.J. Day from Newcastle General Hospital.

A new method for measuring bone mineral content was presented by A. Horsman of the General Infirmary at Leeds. Horsman uses a ^{153}Gd source with a xenon-filled multi-wire proportional counter as detector. He believes that this system achieves better spatial resolution of bone boundaries. Short-term serial measurements on normal subjects indicate that in the forearm a measurement precision of about 2% is possible. (This is also the precision claimed by John Cameron and others using ^{125}I absorptiometric techniques with small NaI detectors).

Another group (P. Tothill, D. Sutton, and B. Condon, all of the Royal Infirmary, Edinburgh) has developed a dual photon absorptiometry technique for measuring the mineral content of the lumbar spine. They use the 60 and 660 keV photons from ^{241}Am and ^{137}Cs and also the 40 and 100 keV photons from ^{153}Gd. The latter has been found to be the most useful. Reproducibility under best conditions is about 3%. Accuracy is being studied by scanning excised vertebrae and comparing with ashed weight.

By way of a final comment, the conference proved to be interesting and informative, and many of the new procedures that were demonstrated or described would seem to represent definite advances in both knowledge and technology.

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